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(54) **SYSTEM AND METHOD TO ACCESS LUNG TISSUE**

(57) A system and method for navigating to a target site in a patient is provided. The system includes an extended working channel (116) and a tool (100) usable with an electromagnetic navigation system (130). In particular, the extended working channel (116) and the tool (100) contain an electromagnetic sensor (120) config-

ured to provide location information within a patient of the extended working channel (116) and the tool (100) to the electromagnetic navigation system (130). The distance from the tool (100) and the target site can then be determined and displayed to a clinician on a display device.

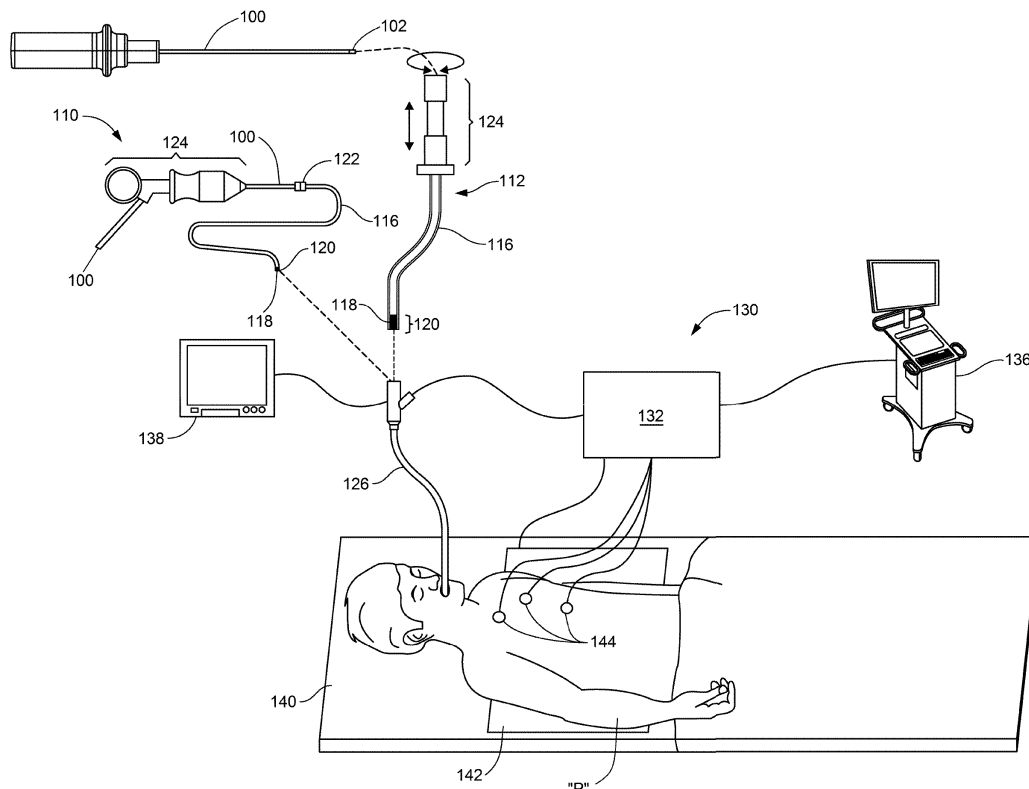


FIG. 1

Description

BACKGROUND

1. *Technical Field*

[0001] The present disclosure relates generally to systems and methods for navigating a tool, such as a catheter, probe, or medical device, through a luminal network of a patient's body to a target site and tracking the location of the tool relative to the target site.

2. *Background of Related Art*

[0002] A common device for inspecting and navigating the airway of a patient is a bronchoscope. Typically, the bronchoscope is inserted into a patient's airways through the patient's nose or mouth and can extend into the lungs of the patient. In navigating to a region of interest, bronchoscopes, however, are limited in how far they may be advanced through the airways due to their size. In instances in which the bronchoscope is too large to be located at a region of interest deep in the lungs, a clinician may advance smaller diameter catheters and/or tools through the bronchoscope to reach the location. To aid in the navigation of the catheter and/or tool through the bronchoscope, the clinician may utilize real-time imaging modalities such as computerized tomographic (CT) images. These images enable the development of three-dimensional models of the airways or other luminal networks, typically from a series of computed tomography (CT) images. While the system described above is quite capable, improvements may be made.

SUMMARY

[0003] Provided in accordance with the present disclosure is a method of navigating a tool to a target site. The method includes first identifying a location of a target site within a patient's body. The location of a tool having a first sensor disposed on the tool is then tracked and a distance between the location of the target site and the tracked location of the tool first sensor is determined. The tracking of the location of the first sensor may include receiving orientation data corresponding to the first sensor. In an embodiment, the tool is a needle, a guide wire, a biopsy tool, a dilator, or an ablation device. The determined distance between the location of the target site and the tool is then displayed. The identification of a location of a target site within a patient's body may include obtaining a plurality of images of the patient's body and then identifying the location of the target site from the plurality of images, the plurality of images may be stored images. The plurality of images may also include computer tomography (CT) images, ultrasound images, magnetic resonance images (MRI), fluoroscopic images, or endoscopic images. Additionally, the location of the target site may be identified by displaying images of the

patient's body and receiving an input on one or more of the images indicating the location of the target site. In one embodiment, the target site may include a biomarker or other localization materials, which can be used to identify the location of the target site and sensed by the first sensor.

[0004] In one embodiment, the method further includes detecting a change in location of the first sensor on the tool and determining a distance between the location of the target site and the change in location of the first sensor. The displayed distance between the location of the target site and the first sensor is then updated. The method may further include the tracking of a location of a second sensor on a catheter configured to receive the tool and determining a distance between the location of the first sensor and the second sensor. The distance between the location of the first sensor and the second sensor is then displayed. The catheter may be an extended working channel (EWC), a needle, a guide wire, a biopsy tool, a dilator, or an ablation device.

[0005] Also provided in accordance with the present disclosure is a navigation system including a tool configured to be advanced through a patient's luminal network, the tool having a first sensor, a display configured to display an image of a portion of the patient's luminal network, a controller coupled to the display, and a memory. The memory stores instructions that when executed by the controller cause the controller to identify a location of a target site within a patient's body, track a location of the tool having the first sensor, determine a distance between the location of the target site and the tool, and display, on the display, the distance between the location of the target site and the tool. The tool may be an extended working channel (EWC), a needle, a guide wire, a biopsy tool, a dilator, or an ablation device. The navigation system may further comprise a catheter configured to receive the tool, the catheter having a second sensor. In an embodiment, the first sensor and/or the second sensor may be an electromagnetic sensor. In an embodiment, the memory further causes the controller to track a location of the catheter having the second sensor, determine a distance between the location of the tool and the catheter, and display, on the display, the distance between the location of the tool and the catheter.

[0006] In an embodiment, the tool is lockable relative to the catheter. The tool can be locked to the catheter with a clip, luer lock, or a thread. In another embodiment, the tool includes a hub wherein the first sensor is disposed circumferentially around the hub.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Various embodiments of the present disclosure are described herein with reference to the drawings wherein:

FIG. 1 is a schematic illustration of an electromagnetic navigation (EMN) system and two catheter

guide assemblies configured to be used with the EMN system, in accordance with an embodiment of the present disclosure;

FIG. 2 is a perspective view of a catheter guide assembly of the EMN system of FIG. 1, in accordance with the present disclosure;

FIG. 2A is an enlarged view of an embodiment of a distal portion of the catheter guide assembly of FIG. 2 indicated by area "A";

FIG. 2B is an enlarged view of an alternative embodiment of the distal portion of the catheter guide assembly of FIG. 2 indicated by area "A";

FIG. 2C is an enlarged view of another alternative embodiment of the distal portion of the catheter guide assembly of FIG. 2 indicated by area "A";

FIG. 3 is a schematic of the components of a workstation that may be implemented in the EMN system of FIG. 1, in accordance with an embodiment of the present disclosure;

FIG. 4 is a flow diagram of a method for navigating a catheter and a tool to a target site, in accordance with an embodiment of the present disclosure;

FIG. 5 is a perspective partial-view of a distal portion of an embodiment of a catheter and a tool in a surgical site, in accordance with the present disclosure;

FIG. 6 is a flow diagram of a method for navigating a catheter and a tool to a target site, in accordance with another embodiment of the present disclosure; and

FIG. 7 is a perspective partial-view of a distal portion of an embodiment of a catheter and a tool in a surgical site, in accordance with another embodiment of the present disclosure.

DETAILED DESCRIPTION

[0008] The present disclosure is directed to a navigation system and a method for determining and displaying the distance between a tool and a target site. Generally, a sensor is included on the tool to thereby permit the sensing and tracking of the tool's location. Using the location of the tool, the system calculates a distance between the tool and the target site, and displays the distance to a user. The system may detect movement of the sensor, causing the distance between the tracked tool and the target site to be recalculated and the display to be updated with the recalculated distance.

[0009] Detailed embodiments of the present disclosure are disclosed herein; however, the disclosed embodiments are merely examples of the disclosure, which may be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present disclosure in virtually any appropriately detailed structure.

[0010] FIG. 1 shows an electromagnetic navigation (EMN) system 130 configured for use with a catheter

guide assembly 110, 112, in accordance with an illustrative embodiment of the present disclosure. The EMN system 130 is configured to utilize computerized tomography (CT) imaging, magnetic resonance imaging (MRI), ultrasonic imaging, endoscopic imaging, fluoroscopic imaging, or another modality to create a roadmap of a patient's lungs. One such EMN system 130 is the ELECTROMAGNETIC NAVIGATION BRONCHOSCOPY® system currently sold by Medtronic Inc. The EMN system 130 generally includes a bronchoscope 126 configured to receive one or more types of catheter guide assemblies 110, 112, monitoring equipment 138, an electromagnetic field generator 142, a tracking module 132, and a workstation 136. FIG. 1 also depicts a patient "P" lying on an operating table 140 including an electromagnetic field generator 142. The positions of a number of reference sensors 144 placed on the patient "P" in the magnetic field generated by the electromagnetic field generator 142 can be determined by the tracking module 132. The EMN system 130 uses the reference sensors 144 to calculate a patient coordinate frame of reference.

[0011] Each of the catheter guide assemblies 110, 112 includes a control handle 124 and an extended working channel (EWC) 116 that is configured to receive a tool 100. The EWC 116 includes an electromagnetic (EM) sensor 120 located on a distal end 118 of the EWC 116. The tool 100 may be any one of a variety of medical devices including, but not limited to, a needle, a guide wire, a biopsy tool, a dilator, or an ablation device. In an embodiment, the tool 100 also includes an EM sensor 102. The EM sensors 102, 120 work in conjunction with the tracking module 132 to enable tracking and navigation of the EM sensors 102, 120 within the magnetic field generated by the electromagnetic field generator 142. In particular, the tracking module 132 enables navigation and tracking of the EM sensors 102, 120, including receiving orientation data corresponding to the EM sensors 102, 120, within a luminal network of a patient "P" to arrive at a target site. EM sensors 102, 120 may be any number of types of location sensors, including ring sensors, optical sensors, radiofrequency sensors, ferromagnetic sensors, hollow sensors, and the like. In an embodiment where EM sensor 120 is a hollow sensor, the hollow sensor can be configured to measure a distance that the tool 100 advances past the distal end 118 of the EWC 116.

[0012] With additional reference to FIG. 2, a catheter guide assembly 110 is shown, in accordance with an embodiment of the present disclosure. In addition to including the EWC 116 and tool 100, the catheter guide assembly 110 includes a control handle 124, which enables advancement and steering of the distal end of the catheter guide assembly 110. Once inserted in the EWC 116, the tool 100 can be locked to the EWC 116 with a locking mechanism 122. The locking of tool 100 to the EWC 116 allows the tool 100 and the EWC 116 to travel together through a luminal network of the patient "P." The locking mechanism 122 may be a simple clip or luer lock, or the

tool 100 may have a threaded configuration that allows it to threadably engage with and lock to the EWC 116. Examples of catheter guide assemblies usable with the instant disclosure are currently marketed and sold by Medtronic Inc. under the name SUPERDIMENSION® Procedure Kits and EDGE™ Procedure Kits. For a more detailed description of the catheter guide assemblies, reference is made to commonly-owned U.S. Patent Application Publication Number 2014/0046315 filed on March 15, 2013, by Ladtkow et al. and U.S. Patent No. 7,233,820, the entire contents of which are incorporated in this disclosure by reference.

[0013] FIG. 2A is an enlarged view of a distal end of the catheter assembly 110 indicated by an encircled area "A" in FIG. 2. Here, the EWC 116 including an EM sensor 120 is shown receiving a tool 100, which on its distal end includes an EM sensor 102. FIG. 2B depicts a different embodiment of the distal end of the catheter assembly 110 except that in this embodiment, the EWC 116 does not include an EM sensor. FIG. 2C depicts yet another embodiment of the catheter assembly 110 in which the EM sensor 102 is disposed at a location that is closer to a proximal end of the tool 100. No matter the particular configuration, the EM sensors 102, 120 on the distal portion of the EWC 116 and/or the tool 100 are sensed by the electromagnetic field produced by the electromagnetic generator, and are used to identify the location of the EWC 116 and/or the tool 100 in the electromagnetic field. The EM sensors 102, 120 are used to navigate the EWC 116 and/or tool 100 through a luminal network of the patient "P." In this particular embodiment, the luminal network is the patient's lung.

[0014] As noted briefly above, the tracking module 132 receives data received from the EM sensors 102, 120 and provides the data to the workstation 136 for use in planning and navigation. Turning now to FIG. 3, in order to operate as described, workstation 136 may include memory 204, processor 202, display 214, network interface 212, input device 216, and/or output module 218. Memory 204 includes any non-transitory computer-readable storage media for storing data and/or software that is executable by processor 202 and which controls the operation of workstation 136. In an embodiment, memory 204 may include one or more solid-state storage devices such as flash memory chips. Alternatively or in addition to the one or more solid-state storage devices, memory 204 may include one or more mass storage devices connected to the processor 202 through a mass storage controller (not shown) and a communications bus (not shown).

[0015] Memory 204 may store application 208 and/or image data 206. Application 208 may, when executed by processor 202 cause a display associated with workstation 136 to present user interface 210. Network interface 212 may be configured to connect to a network such as a local area network (LAN) consisting of a wired network and/or a wireless network, a wide area network (WAN), a wireless mobile network, a Bluetooth network, and/or

the internet. Input device 216 may be any device by means of which a user may interact with workstation 136, such as, for example, a mouse, keyboard, foot pedal, touch screen, and/or voice interface. Output module 218 may include any connectivity port or bus, such as, for example, parallel ports, serial ports, universal serial busses (USB), or any other similar connectivity port known to those skilled in the art.

[0016] Prior to the start of navigation, a clinician loads a navigation plan into application 208 from memory 204, a USB device, or from network interface 212. During a procedure planning phase, the workstation 136 utilizes computed tomographic (CT) image data or other image data obtained using a different modality, for generating and viewing a three-dimensional model of patient "P's" airways. This process enables the identification of target site "T" (shown in FIG. 5A) to be navigated to in the image data and to coordinate that target with a three-dimensional model (automatically, semi-automatically, or manually). The planning software allows for the selection of a pathway through the patient "P's" airways to target site "T." More specifically, the CT scans are processed and assembled into a three-dimensional CT volume, which is then utilized to generate a three-dimensional model of the patient "P's" airways. The three-dimensional model of the patient "P's" airways may be displayed on a display associated with workstation 136, or in any other suitable fashion. Using the workstation 136, various views of the three-dimensional model of the patient "P's" airways or two-dimensional images generated from the three-dimensional model of the patient "P's" airways may be presented. The three-dimensional model of the patient "P's" airways or the two-dimensional images of the patient "P's" airways may be manipulated to facilitate identification of target site "T." Additionally, the target site may be identified by detecting a biomarker placed at the target site. The biomarker may also be the tool 100. Thereafter, a suitable pathway through patient "P's" airways to access target site "T" can be selected. After a suitable pathway is selected, the pathway is saved and exported to a navigation component of the software for use during the navigation phase(s).

[0017] Once the pathway to the target is selected, the EMN system 130 utilizes the EM sensors 102, 120 on the EWC 116 in conjunction with the tracking module 132 to enable tracking and navigation of the EM sensor 102, 120 towards the target site "T." As shown in FIG. 1, the clinician inserts a catheter guide assembly 110, 112 including an EM sensor 102, 120 into a bronchoscope 126 for navigation through a patient "P's" airways. Utilizing the tracking module 132, the location of the EM sensor 102, 120 within the three-dimensional model of the patient "P's" airways can be viewed on the workstation. Using the location of the EM sensor 102, 120 and the three-dimensional model of the patient "P's" airways, the clinician can maneuver and guide the EWC 116 and the tool 100 to the target site "T."

[0018] With additional reference now to FIG. 4, a flow-

chart is provided of a computer-implemented method 400 of navigating to a target site "T" and tracking the distance of a tool 100 to a target site "T." The method 400 may be implemented, at least in part, by the processor 202 executing instructions stored in the memory 204 (FIG. 3). Additionally, the particular sequence of steps shown in the method 400 may be executed in sequences other than the sequence shown in FIG. 4 without departing from the scope of the present disclosure. Further, some steps shown in method 400 of FIG. 4 may be concurrently executed with respect to one another instead of sequentially executed with respect to one another.

[0019] In an embodiment, the method 400 starts with a plurality of images of a patient being received at S401. For example, the plurality of images may be images of a patient's body that are captured using one or more of a variety of imaging modalities including, but not limited to, computerized tomography (CT) imaging, magnetic resonance imaging (MRI), ultrasound imaging, endoscopic imaging, or fluoroscopic imaging.

[0020] At S402, a target site "T" is identified within the patient's body using the images. As described in further detail above, in an embodiment, one or more of the plurality of images obtained in S401 are used by the EMN system 130 to identify and plan a pathway to reach the target site "T."

[0021] As shown in FIG. 4, an electromagnetic field generator generates an electromagnetic field around the patient in S403. In this regard, a number of reference sensors 144 placed on the patient "P." The electromagnetic field generator 142 and the reference sensors 144 are interconnected with tracking module 142, which derives the location of each reference sensor 144 in six degrees of freedom. The six degrees of freedom coordinates of reference sensors 144 are sent to workstation 136 where reference sensors 144 are used to calculate a patient coordinate frame of reference.

[0022] Next, the location of a catheter and/or a tool is tracked at step S404. For example, a catheter, such as EWC 116, is inserted into the patient, where the catheter includes a first EM sensor 120. In an embodiment, the EWC 116 is inserted into a bronchoscope 126. A tool 100 having a second EM sensor 102 is then advanced through the EWC 116. Using the pathway selected during the planning phase, described in detail above, the EWC 116 and tool 102 are navigated towards a target site "T," as shown in FIG. 5. Utilizing the electromagnetic field generator 142 and the reference sensors 144 interconnected with tracking module 142, the EMN system 130 tracks the location of both the EM sensor 120 on the EWC 116 or catheter and the EM sensor 102 on the tool within the patient coordinate frame of reference in S404.

[0023] A detection is made as to a change in the location of the tool at step S405. For example, after the EWC 116 and the tool 100 are navigated towards the target site "T," the workstation of EMN system 130 calculates the distance "D1" (shown in FIG. 5) between the distal ends of the EWC 116 and the tool 100 using the EM

sensors 102, 120. In an embodiment, the distance "D1" is zero when the distal end of tool 100 is aligned with the distal end of the EWC 116 so that as the tool 100 is advanced past the distal end of the EWC 116, the distance "D1" increases and the change in location of the tool 100 is detected.

[0024] A distance is then determined between the tool and a target site, at step S406. For example, workstation 136 calculates the distance between the tool 100 and the target site "T". In an embodiment, since the location of the target site "T" is known based on the acquired CT images and generated planned pathway, the distance "D2" from the EWC 116 and the target site can also be determined. As the tool 100 is advanced past the EWC 116, the distance from the tool 100 to the target site "T" can also be determined.

[0025] The determined distance between the EWC 116 and the tool is displayed at step 407. According to an embodiment, the calculated distance "D2" from the EWC 116 and the target site can then be displayed to a user by workstation 136 in real time.

[0026] In another embodiment, in addition to the performance of step S406, a distance is calculated between the EWC 116 and the tool 100, at step S406a. As noted above, as a result of the detection of the change of location of the tool 100 in step S405, the distance "D1" may be calculated to indicate the distance the tool 100 is advanced past the EWC 116. Likewise, the calculated distance may be displayed at step S407. For example, the distance "D1" from the EWC 116 and the tool 100 can be displayed to the user. In another embodiment, as shown in FIG. 2C, the EM sensor 102 may be disposed at a location that is closer to a proximal end of the tool 100. In such an embodiment, the EM sensor 102 may not extend outside of the EWC 116. As the tool 100 advances forward, the EM sensor 102 inside the EWC 116 progressively moves toward the EM sensor 120 of the EWC 116, and the distance between the EM sensor 102 inside of the EWC 116 and the EM sensor 120 of the EWC 116 can then be used to determine the distance "D1" between the distal end of the tool 100 and the EM sensor 120.

[0027] In S408, a determination is made as to whether the tool 100 has advanced to the target site "T." For example, a determination is made as to whether the distance between the tool 100 and the target site "T" is zero. If the tool 100 has not yet reached the target site "T," the tool 100 is advanced through the EWC 116 or catheter and the method 400 reiterates at S405. As the display is updated at step 407, the display effectively provides a "counting-down" of the distance the tool 100 needs to be advanced before it reaches the target "T." For example, the workstation 136 updates the display to display the updated distance "D2" between the tool 100 and the target site "T." Likewise, the updated distance "D1" between the EWC 116 and tool 100 can be displayed. Returning to step S408, if a determination has been made that the tool 100 has reached the target site "T" the process is

complete. The tool 100 may then be used to treat the target site "T" and/or it may be removed to allow a different tool to be inserted through the EWC 116 or catheter.

[0028] With reference now to FIG. 6, a flowchart is provided of a computer-implemented method 600 of navigating to a target site "T" and tracking the distance of a tool 100 to a target site "T," according to another embodiment. The method 600 may be implemented, at least in part, by the processor 202 executing instructions stored in the memory 204 (FIG. 3). Additionally, the particular sequence of steps shown in the method 600 may be executed in sequences other than the sequence shown in FIG. 6 without departing from the scope of the present disclosure. Further, some steps shown in method 600 of FIG. 6 may be concurrently executed with respect to one another instead of sequentially executed with respect to one another. The method 600 of FIG. 6 is described with reference to FIG. 7.

[0029] Steps S601 to S604 are performed in a manner substantially similar to steps S401 to S404 of FIG. 4, respectively. At step S605, a detection is made as to a change in the location of the tool. For example, when the distal end of tool 100 is aligned with the distal end of the EWC 116, the distance is zero. However, as the tool 100 is advanced past the distal end of the EWC 116 (or retracted), the distance between the two increases (or decreases) and the change in location of the tool 100 is detected. In an embodiment in which the distal end of the tool 100 is advanced past the distal end of the EWC 116, as shown in FIG. 7, the distal end of the tool 100 may be placed at a location "P1".

[0030] A distance is then determined between the tool and a target site, at step S606. For example, workstation 136 calculates the distance between the tool 100 and the target site "T" using the sensor 102 on the distal end of the tool 100. In an embodiment, since the location of the target site "T" is known based on the acquired CT images and generated planned pathway, the distance "D2" from the EWC 116 (for example, via the sensor 120) and the target site "T" can also be determined. In particular, as the tool 100 is advanced past the EWC 116, the distance from the tool 100 to the target site "T" can also be determined (for example, the distance "D4" in FIG. 7).

[0031] The determined distance between the EWC 116 and the tool is displayed at step S607. According to an embodiment, the calculated distance "D2" from the EWC 116 and the target site "T" can then be displayed to a user by workstation 136 in real time. Likewise, the distance "D4" between the tool 100 and the target site "T" is displayed to a user by workstation 136 in real time, effectively "counting down" the distance remaining to the target site "T."

[0032] In another embodiment, in addition to the performance of step S606, a distance is calculated between the EWC 116 and the tool 100, at step S606a. As a result of the detection of the change of location of the tool 100 in step S605, the distance "D1" may be calculated to indicate the distance the tool 100 has been advanced

past the EWC 116. Likewise, the calculated distance may be displayed at step S607. For example, the distance "D1" from the EWC 116 and the tool 100 can be displayed to the user.

[0033] In step S608, workstation 136 stores a tracked location of the EWC 116, or catheter, and a tracked location of the tool 100 in memory 204. For example, referring to FIG. 7, the location "P1" at a distal end of the tool 100 when the distance is "D1" may be stored. As the tool 100 is advanced, a change in the location of the tool 100 is detected in step S609, for example, to location "P2". The change in distance "D3" between the new location "P2" of the tool 100 and the stored location "P1" of the tool 100 is then determined in S610. Hence, as the tool 100 is advanced past the distal end of EWC 116, the distance from the tool 100 to the target site "T" also changes. In particular, the change in location of the tool 100 is determined to be "D3." As the distance "D3" increases, the distance "D4" from the distal end of tool 100 to the target site "T" decreases in an equal amount.

[0034] The new distance "D5" between the new location "P2" of tool 100 and the target site "T" is then determined in step S611a. Additionally, the distance between the new location of tool 100 and the EWC 116 is also determined in step S611b. The can be determined adding the distance "D3" with distance "D1" to yield the distance "D6". As such, as the distance "D3" increases, the distance from the EWC 116 to the distal end of the tool 100 "D6" increases in an equal amount.

[0035] In step S612, the distance between the EWC 116 and the tool 100 "D6" and/or the distance "D5" between the tool 100 and the target site "T" are displayed on workstation 136. Additionally or alternatively, the change in distance "D3" between the new location of tool 100 and the stored location of tool 100 can also be displayed. The displayed distances can be continually updated to present a live "count-down" of the distance remaining from the tool 100 to the target site "T."

[0036] In step S613, a determination is made as to whether the tool 100 has advanced to the target site "T." For example, a determination is made as to whether the distance between the tool 100 and the target site "T" is zero. If the tool 100 has not yet reached the target site "T," the tool 100 is advanced through the EWC 116 or catheter and the method 400 reiterates at S609.

[0037] Returning to step S613, if a determination has been made that the tool 100 has reached the target site "T" the process is complete. The tool 100 may then be used to treat the target site "T" and/or it may be removed to allow a different tool to be inserted through the EWC 116 or catheter.

[0038] While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting but merely as exemplifications of particular embodiments.

Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

[0039] The invention is described by the following numbered paragraphs:-

1. A navigation system comprising:

a tool configured to be advanced through a patient's luminal network, the tool having a first sensor;
a display configured to display an image of a portion of a patient's luminal network;
a controller coupled to the display; and
a memory storing instructions that when executed by the controller cause the controller to:

identify a location of a target site within a patient's body;
track a location of the tool having the first sensor;
determine a distance between the location of a target site and the tool; and
display, on the display, the distance between the location of a target site and the tool.

2. The navigation system according to paragraph 1, wherein the tool is an extended working channel (EWC), a needle, a guide wire, a biopsy tool, a dilator, or an ablation device.

3. The navigation system according to paragraph 1, wherein the first sensor is an electromagnetic sensor.

4. The navigation system according to paragraph 1, further comprising a catheter configured to receive the tool, the catheter having a second sensor.

5. The navigation system according to paragraph 4, wherein the memory further causes the controller to:

track a location of the catheter having the second sensor;
determine a distance between the location of the tool and the catheter; and
display, on the display, the distance between the location of the tool and the catheter.

6. The navigation system according to paragraph 1, wherein the second sensor is an electromagnetic sensor.

7. The navigation system according to paragraph 4, wherein the tool is lockable relative to the catheter.

8. The navigation system according to paragraph 7, wherein the tool is locked to the catheter with a clip,

luer lock, or a thread.

9. The navigation system according to paragraph 1, wherein the tool includes a hub and wherein the first sensor is disposed circumferentially around the hub.

Claims

1. A navigation system comprising:

a tool configured to be advanced through a patient's luminal network, the tool having a first sensor;
a display configured to display an image of a portion of a patient's luminal network;
a controller coupled to the display; and
a memory storing instructions that when executed by the controller cause the controller to:

identify a location of a target site within a patient's body;
track a location of the tool having the first sensor;
determine a distance between the location of a target site and the tool; and
display, on the display, the distance between the location of a target site and the tool.

2. The navigation system according to claim 1, wherein the tool is an extended working channel (EWC), a needle, a guide wire, a biopsy tool, a dilator, or an ablation device.

3. The navigation system according to claim 1 or 2, wherein the first sensor is an electromagnetic sensor.

4. The navigation system according to claim 1, 2 or 3, further comprising a catheter configured to receive the tool, the catheter having a second sensor.

5. The navigation system according to claim 4, wherein the memory further stores instructions that when executed by the controller cause the controller to:

track a location of the catheter having the second sensor;
determine a distance between the location of the tool and the catheter; and
display, on the display, the distance between the location of the tool and the catheter.

6. The navigation system according to claim 4 or 5, wherein the second sensor is an electromagnetic sensor.

7. The navigation system according to claim 4, 5 or 6,
wherein the tool is lockable relative to the catheter.
8. The navigation system according to claim 7, comprising a clip, luer lock, or a thread for locking the tool to the catheter. 5
9. The navigation system according to any preceding claim, wherein the tool includes a hub and wherein the first sensor is disposed circumferentially around the hub. 10

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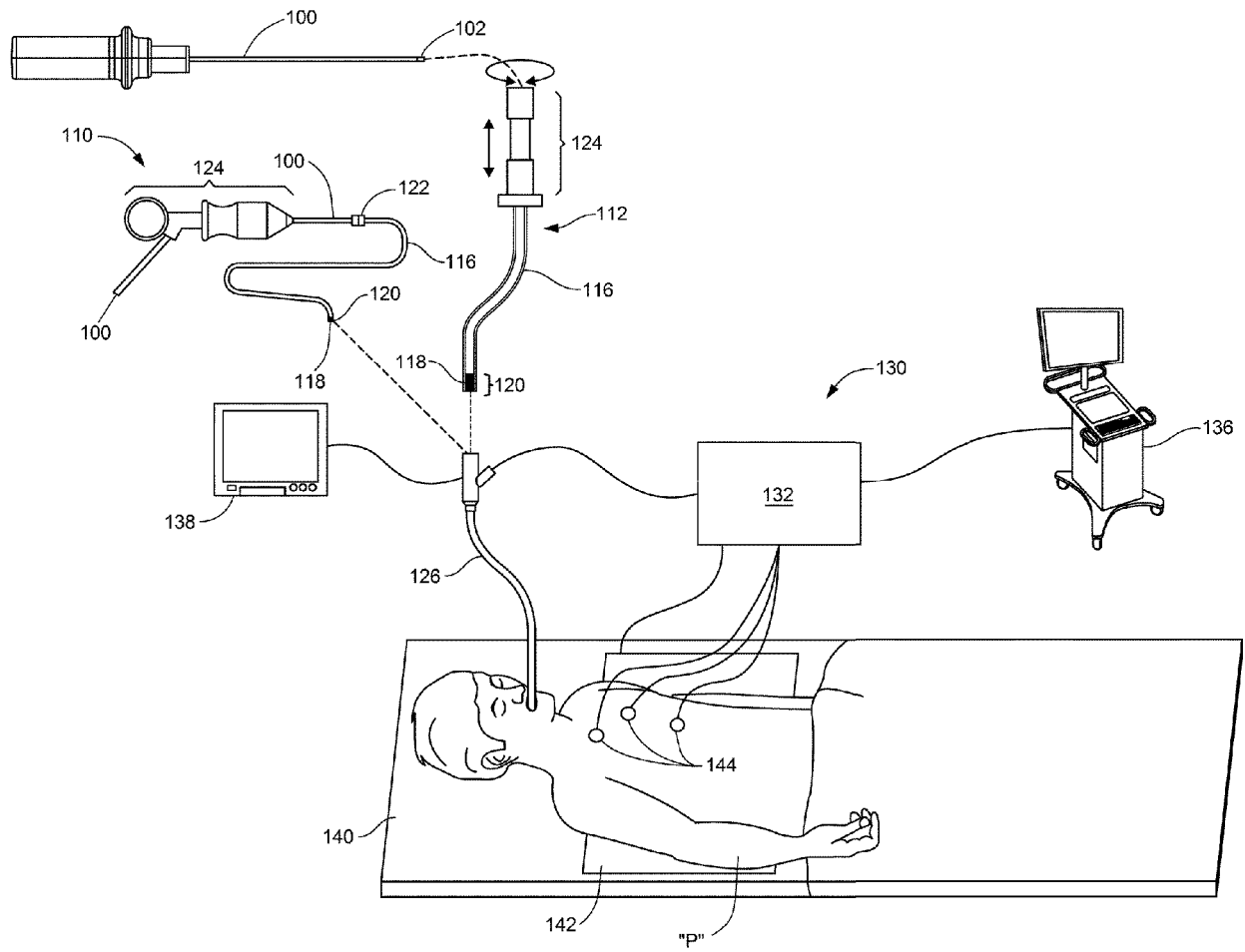
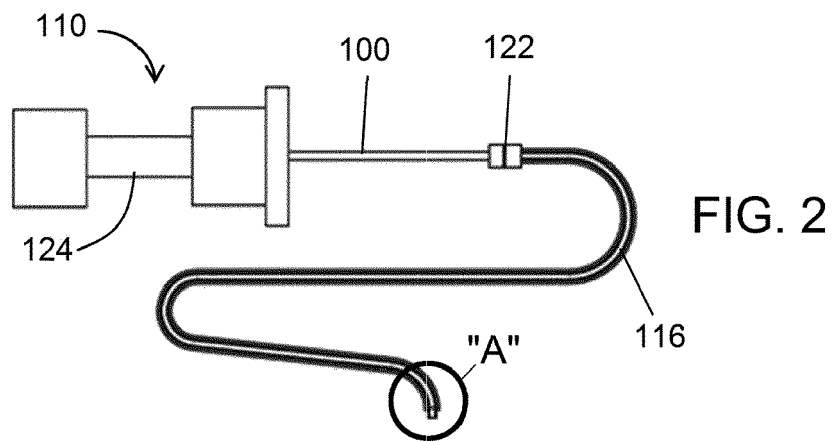


FIG. 1



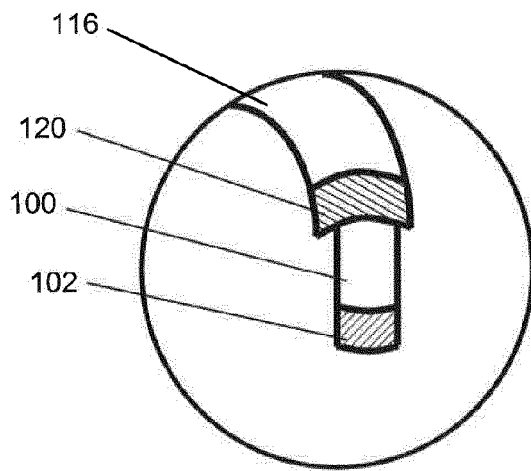


FIG. 2A

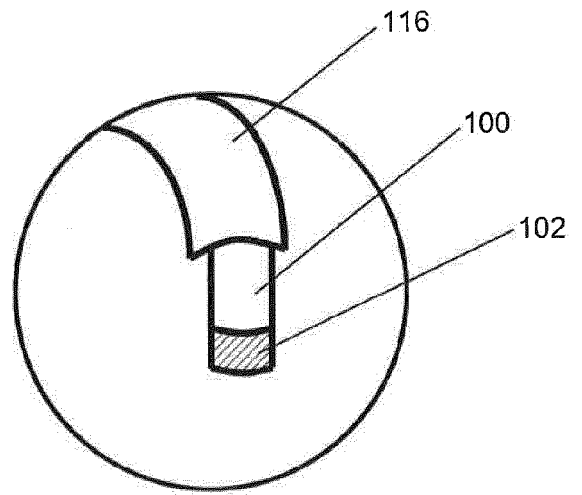


FIG. 2B

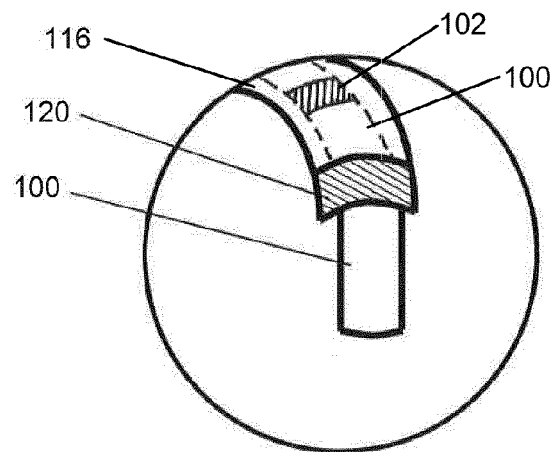


FIG. 2C

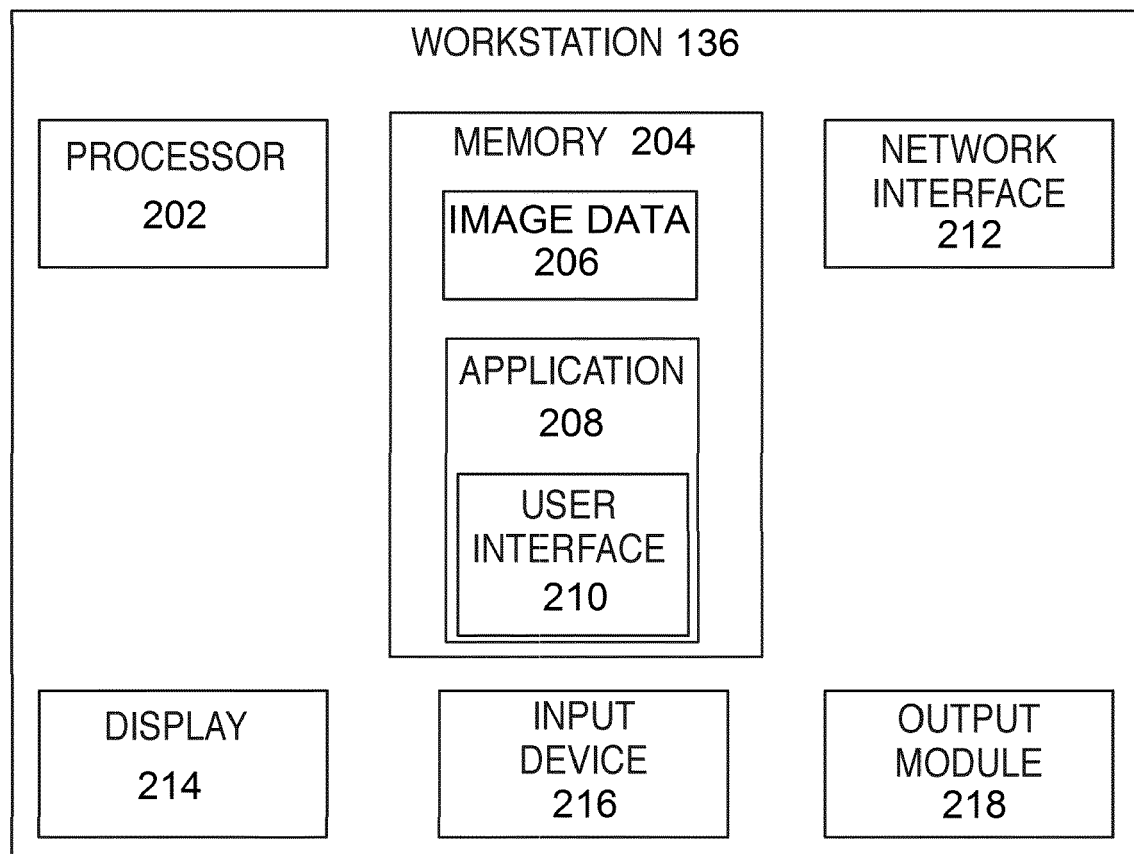


FIG. 3

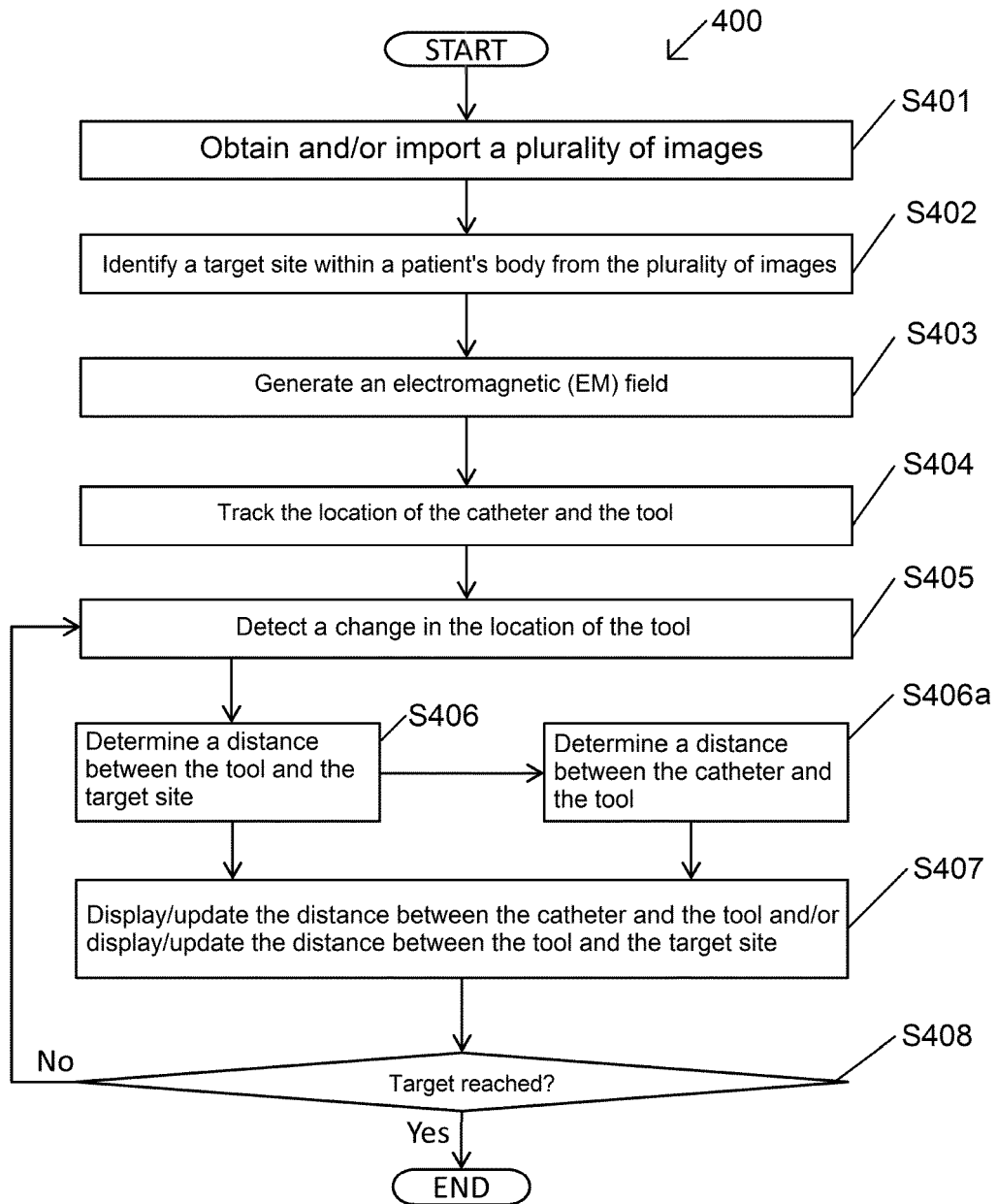


FIG. 4

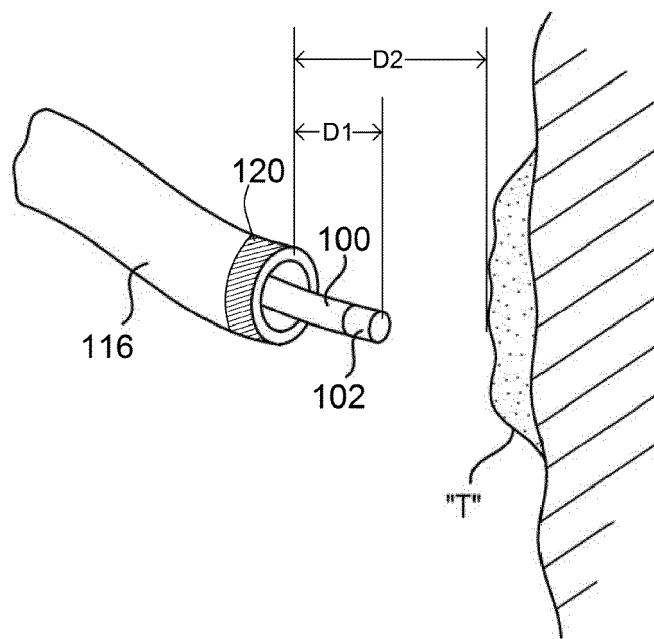


FIG. 5

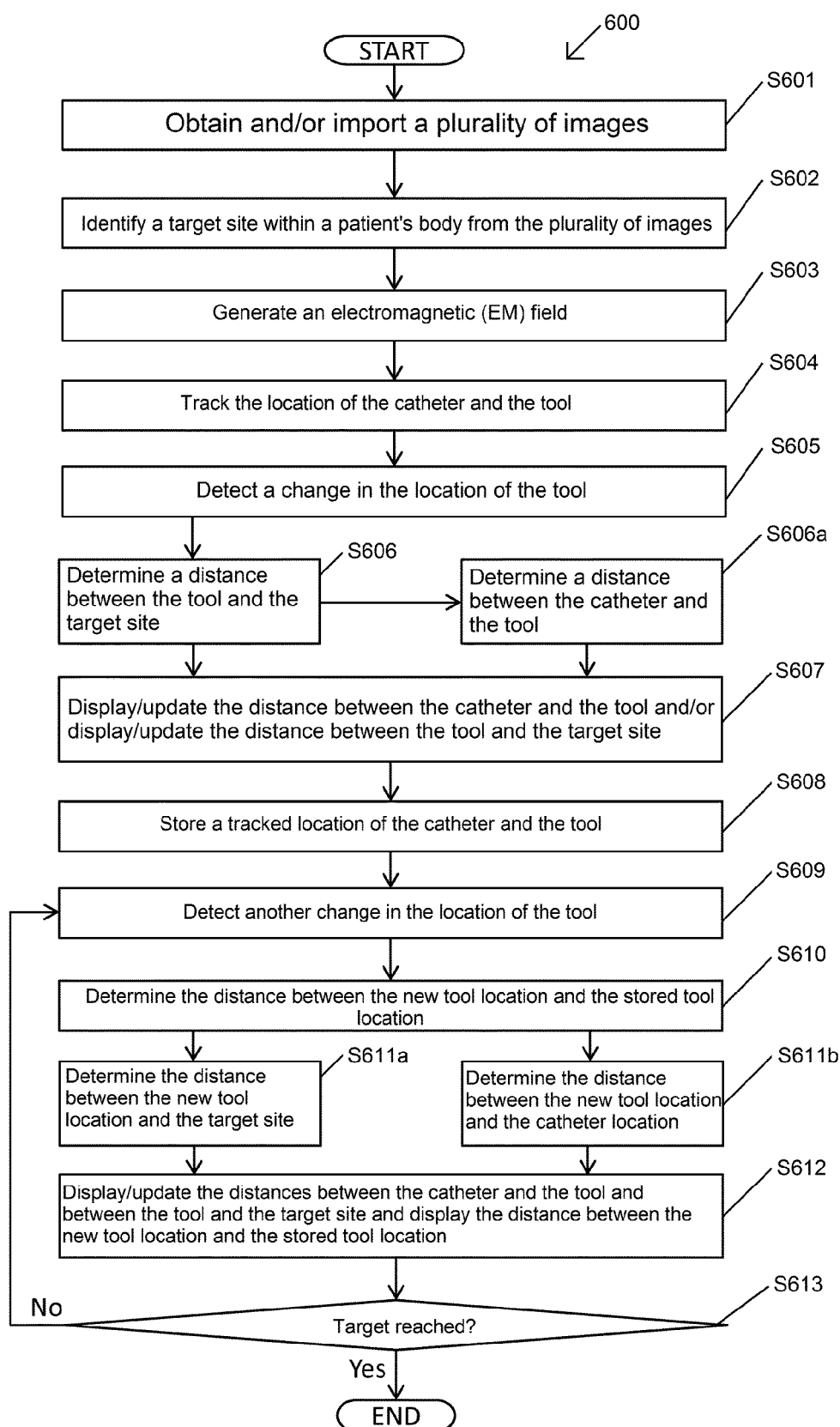


FIG. 6

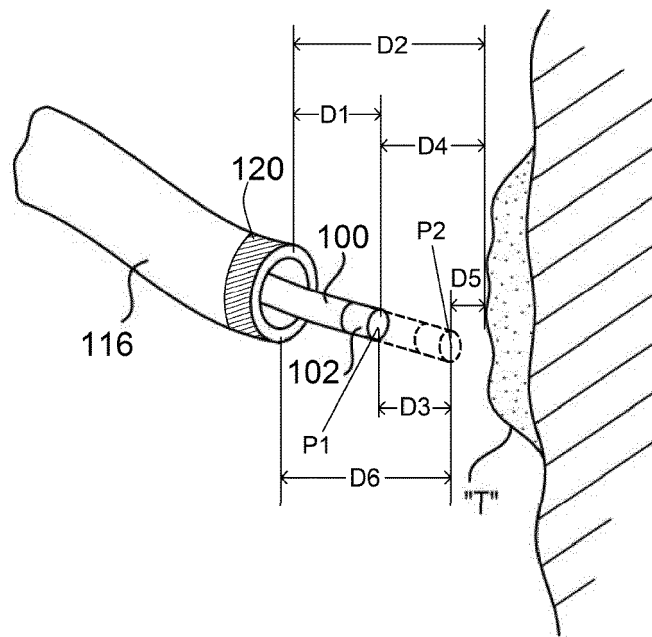


FIG. 7



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Place of search Munich		Date of completion of the search 28 August 2017	Examiner Enborg, Andreas	
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